

Morphological Examination of Stink Bug (Heteroptera: Pentatomidae) Eggs on Cotton and Soybeans, with a Key to Genera

Author(s): C. S. Bundy and R. M. McPherson

Source: Annals of the Entomological Society of America, 93(3):616-624. 2000.

Published By: Entomological Society of America

DOI: [http://dx.doi.org/10.1603/0013-8746\(2000\)093\[0616:MEOSBH\]2.0.CO;2](http://dx.doi.org/10.1603/0013-8746(2000)093[0616:MEOSBH]2.0.CO;2)

URL: <http://www.bioone.org/doi/full/10.1603/0013-8746%282000%29093%5B0616%3AMEOSBH%5D2.0.CO%3B2>

BioOne (www.bioone.org) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/page/terms_of_use.

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

Morphological Examination of Stink Bug (Heteroptera: Pentatomidae) Eggs on Cotton and Soybeans, with a Key to Genera

C. S. BUNDY AND R. M. MCPHERSON

Department of Entomology, Coastal Plain Experiment Station, University of Georgia, Tifton, GA 31793

Ann. Entomol. Soc. Am. 93(3): 616-624 (2000)

ABSTRACT The eggs of 10 species of stink bugs found on cotton or soybeans are described, including size, chorion, and number and length of the micropylar processes; electron micrographs are provided for each species. In addition, egg size and length of the processes are compared among the species. Eggs of *Acrosternum hilare* (Say) and *Thyanta custator accerra* McAtee were the largest and smallest, respectively. Eggs of *Podisus maculiventris* (Say) had the longest micropylar processes, followed by those of *Piezodorus guildinii* (Westwood). The smallest processes were those of *T. c. accerra*. The number of micropylar processes ranged from 19 in *P. maculiventris* to 79 in *Oebalus pugnax* (F.). In addition, to these characters, the number of eggs per egg mass and the North American distributions of each species is given. Finally, a key is presented for identification of the pentatomid eggs found on cotton and soybeans in the southeastern United States.

KEY WORDS *Acrosternum hilare*, *Euschistus*, *Nezara viridula*, *Podisus maculiventris*, egg, key

SOME STINK BUGS are important pests of cotton and soybeans in the southeastern United States. In Georgia alone, pentatomids were responsible for over \$3.1 million in cotton losses and control costs in 1996 (Riley et al. 1997). They also are among the most important pests in soybeans and were the most damaging pests of this crop in Georgia in 1996, causing nearly \$2.3 million in total losses (Riley et al. 1997). Losses in Georgia soybeans from stink bugs may reach as high as \$13 million in some years (Douce and McPherson 1991).

In the southeastern United States, the most important pentatomid pests in both crops are the southern green stink bug, *Nezara viridula* (L.); the green stink bug, *Acrosternum hilare* (Say); and the brown stink bug, *Euschistus servus* (Say) (Roach 1988; McPherson et al. 1993, 1995). Other phytophagous stink bugs associated with soybeans in the southeast include *Euschistus obscurus* (Palisot de Beavois), *Euschistus quadror* Rolston, *Euschistus tristigmus* (Say), *Oebalus pugnax* (F.), *Piezodorus guildinii* (Westwood), and *Thyanta custator accerra* McAtee (Panizzi and Slansky 1985, McPherson et al. 1993). Additional pentatomid pest species associated with cotton include *E. quadror*, *E. tristigmus*, and *T. c. accerra* (Barbour et al. 1988, Bundy et al. 1998).

In cotton, pentatomids feed on developing seeds and lint (Barbour et al. 1988). The result of feeding includes the shedding of young bolls, yellowing of lint, and reduction in harvestable locks (Wene and Sheets 1964, Roach 1988). In soybeans, stink bugs feed on seeds, foliage, blooms, and stems of the plant (McPherson et al. 1994). This feeding results in shriveled and discolored seed (McPherson et al. 1994),

reduction in oil content (Daugherty et al. 1964), and reduction in yield (McPherson 1996).

In contrast to the detrimental effects of the feeding of phytophagous stink bugs, some pentatomids are beneficial. Asopine stink bugs are predators that feed on a wide range of arthropods. One of the most commonly collected predaceous stink bugs found in soybeans and cotton is *Podisus maculiventris* (Say), the spined soldier bug (Whitcomb and Bell 1964, Deitz et al. 1976). It has been implicated as an important agent of biological control and feeds upon many important pest species (Marston et al. 1978, J. McPherson 1982, Wiedenmann et al. 1996).

The egg remains the least-studied stage of development of these important insects. Southwood (1956) gave an excellent discussion on the morphology of the eggs of the terrestrial Heteroptera. Heidemann (1911) briefly reviewed this broad group for North America. Coppel and Jones (1962) examined the species of *Podisus* associated with a pine sawfly in Wisconsin and provided a key to the eggs of those species. Esselbaugh (1946) published the most comprehensive work on pentatomid eggs. However, he did not indicate the number of eggs examined for the descriptions and key provided. Additionally, the focus of his work was not limited to those species associated with specific crops. Therefore, not all species present in cotton and soybeans were included in his article.

Pentatomid eggs are deposited in an upright position and glued to the substrate and one another to form clusters that are variable in number, depending upon the species. Those of phytophagous species may be laid on the leaves, stems, or fruiting structures of the host plant (Underhill 1934, Esselbaugh 1946, Southwood 1956). Predaceous stink bugs such as

P. maculiventris have been reported to deposit eggs on the upper surface of leaves (Esselbaugh 1946); however, eggs also are deposited on the undersides of leaves (C.S.B., unpublished data).

Materials and Methods

Stink bug adults were collected in the field in Georgia and transported to the laboratory for identification. Males and females of each species were held in cages, which were placed in a large, walk-in incubator room, and maintained at 27°C under a photoperiod of 14:10 (L:D) h. Cages consisted of plastic storage containers (28 by 15 by 11 cm) with well-fitting lids. A portion of the lid was cut away, and fine screen netting was glued to it to allow air circulation within the cage. In each cage, small, closed plastic dishes were filled with distilled water, and cotton dental wicks were exposed through circular openings in the tops of the dishes so the stink bugs could obtain moisture without the potential for drowning. The bugs were fed fresh green beans, *Phaseolus vulgaris* L., which were replaced 2–3 times each week. Strips of cheesecloth were draped in each cage to provide ovipositional sites for gravid females.

Cages were checked daily for eggs. Sections of cheesecloth with attached egg clusters were removed and transferred to petri dishes containing filter paper moistened with distilled water to prevent desiccation. Mature eggs—those in which a mature embryo was visible—were preserved in 80% EtOH; these eggs were used to avoid nonviable eggs that might have atypical or incomplete chorionic development. Eggs were later examined with a dissecting microscope. Measurements (50 eggs) were taken of the egg length, egg diameter, and micropyle length of each species with the aid of an ocular micrometer and a dissecting microscope. The numbers of micropylar processes also were recorded for each species. Additionally, eggs of each species were examined using a scanning electron microscope to make more detailed observations of their morphology. Measurements of these species were analyzed using a completely randomized analysis of variance, and means were separated using the Duncan multiple range test with $P = 0.05$ (SAS Institute 1989). Voucher specimens of the eggs of all species are deposited in the University of Georgia Collection of Arthropods in Athens, GA.

Results

Eggs of pentatomids typically become pinkish upon reaching maturity. This change in color resides primarily in the red eyespots and other body regions of the developing embryo. Unless otherwise indicated, the color of the eggs described below will follow this pattern when mature.

Acrosternum hilare (Say), the green stink bug (Fig. 1a–b). Length, 1.22–1.53 mm, diameter, 1.04–1.29 mm.

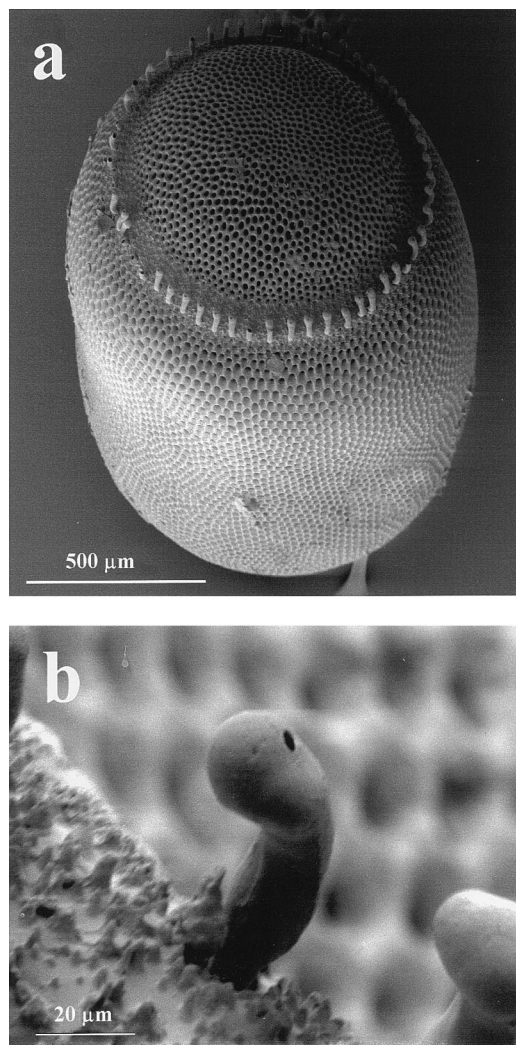


Fig. 1. *A. hilare* (Say). (a) Lateral view of chorion. (b) Micropylar process.

Sides slightly arcuate. Operculum convex and circular. Chorion coarsely reticulate, foveate. Micropylar processes 47–64, clavate and decurved. Surface of micropyle appearing smooth. Micropylar aperture located dorsally near apex of micropyle. Average micropylar length, 0.07 mm (Table 1). Color lemon yellow or pea green. The egg mass of this species has been reported to consist of a maximum of from 40 to 69 eggs (Whitmarsh 1917, Sorenson and Anthon 1936, Esselbaugh 1946). Egg masses of up to 69 eggs also were observed in the current study. Eggs are deposited in uniform rows and arranged somewhat loosely.

The green stink bug is a widespread species that ranges from Quebec and Massachusetts south to Florida and west to California (Froeschner 1988). It is one of the most common pest species in both cotton and soybeans in the Southeast (Barbour et al. 1988, McPherson et al. 1994, McPherson 1996; C.S.B., unpublished data).

Table 1. Comparisons of mean egg measurements among several pentatomid species

Species	Length, mm ^a	Diameter, mm ^a	Micropylar length, mm ^a	No. micropyles per egg	Sample size
<i>A. hilare</i>	1.39 ± .010a	1.16 ± .007a	0.07 ± .001d	56	100
<i>E. obscurus</i>	1.10 ± .005c	0.94 ± .004bc	0.05 ± .001e	31	100
<i>E. quadrator</i>	0.93 ± .005f	0.76 ± .005f	0.08 ± .002c	35	201
<i>E. servus</i>	1.08 ± .007d	0.95 ± .008b	0.05 ± .001e	34	50
<i>E. tristignus</i>	1.06 ± .006d	0.93 ± .005c	0.05 ± .001e	33	84
<i>N. viridula</i>	1.12 ± .007b	0.78 ± .003e	0.04 ± .001f	33	130
<i>O. pugnax</i>	0.84 ± .004g	0.63 ± .003h	0.04 ± .001f	67	100
<i>P. guildinii</i>	1.00 ± .008e	0.69 ± .006g	0.11 ± .002b	40	122
<i>P. maculiventris</i>	1.00 ± .005e	0.88 ± .007d	0.29 ± .002a	16	130
<i>T. accerra</i>	0.99 ± .004e	0.79 ± .004e	0.03 ± .001g	22	102

^a n = 50. Column means (±SE) followed by the same letter are not significantly different using Duncan multiple range test, *P* = 0.05.

Euschistus obscurus (Palisot) (Fig. 2a–b). Length, 1.00–1.14 mm; diameter, 0.88–0.98 mm. Form subelliptical. Operculum weakly convex and circular. Chorion spinose, with sculpturing in a weakly defined triangular pattern. Micropylar processes 26–39, weakly clavate. Surface of micropyle porous. Micro-

pylar aperture located at apex of micropyle. Average micropylar length, 0.05 mm (Table 1). Color white or cream.

No previous reports have been given on the size of the egg mass of this insect. Egg masses of up to 32 eggs were observed during this study. Eggs were arranged loosely in a slightly irregular cluster. See discussion for comparisons of the *Euschistus* species.

This species has a southern distribution and has been reported in the United States from Florida, Georgia, Mississippi, and Texas (Froeschner 1988). However, it probably is present in the other Gulf Coast states as well. This insect has been collected in low numbers from soybeans (McPherson et al. 1993) and cotton (C.S.B., unpublished data).

Euschistus quadrator Rolston (Fig. 3a and 3b). Length, 0.88–0.98 mm; diameter, 0.69–0.82 mm. Form subelliptical. Operculum weakly convex and circular. Chorion spinose, with sculpturing in a weakly defined triangular pattern. Micropylar processes 29–39, weakly clavate. Surface of micropyle porous. Micropylar aperture located at apex of micropyle. Average micropylar length, 0.08 mm (Table 1). Color white or cream.

No previous reports have been given on the size of the egg mass of this insect. Egg masses consisting of up to 25 eggs were observed during this study. As with *E. obscurus*, eggs were loosely arranged in a slightly irregular cluster.

Euschistus quadrator is a southern species which has been reported from the United States in Louisiana (Rolston 1974) and Georgia (McPherson et al. 1993). This is an uncommonly collected species which may be found in both soybean (McPherson et al. 1993) and cotton (C.S.B., unpublished data).

Euschistus servus (Say), the brown stink bug (Fig. 4a–4b). Length, 0.98–1.18 mm; diameter, 0.86–1.10 mm. Form subelliptical. Operculum weakly convex and circular. Chorion spinose, with sculpturing in a weakly defined triangular pattern. Micropylar processes 26–39, weakly clavate. Surface of micropyle porous. Micropylar aperture located at apex of micropyle. Average micropylar length, 0.05 mm (Table 1). Color white or cream.

The egg mass of this species has been reported to reach a maximum of from 28 (Woodside 1946) to 55

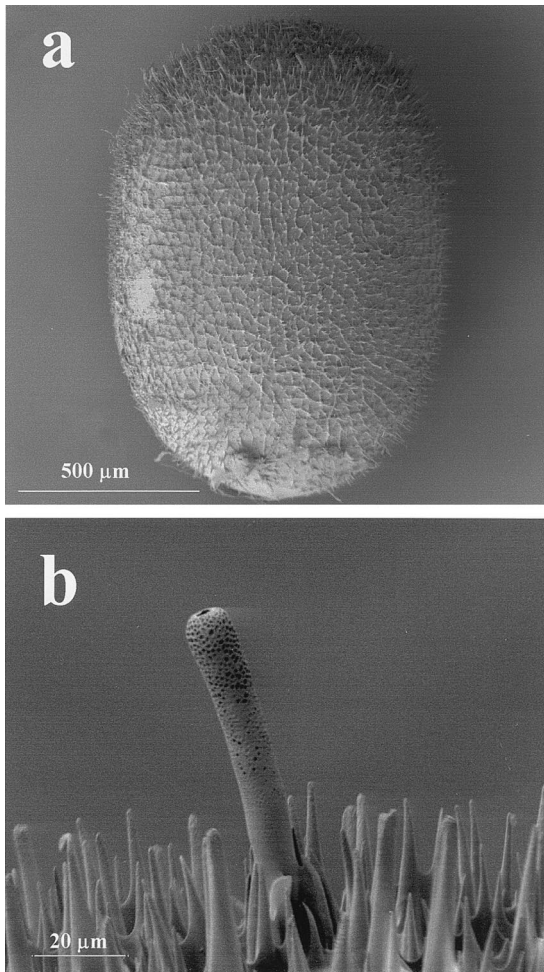


Fig. 2. *E. obscurus* (Palisot). (a) Lateral view of chorion. (b) Micropylar process.

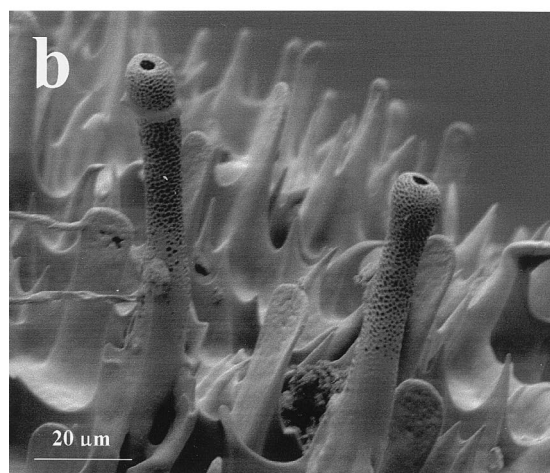
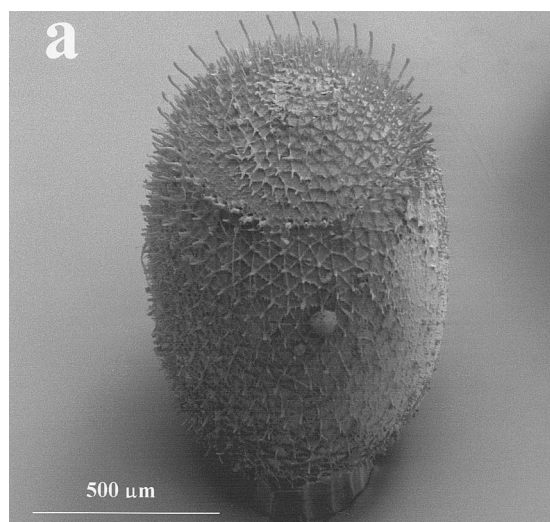


Fig. 3. *E. quadrator* Rolston. (a) Lateral view of chorion. (b) Micropylar processes.

eggs per cluster (Esselbaugh 1946). A maximum of 35 eggs per cluster was observed during this study. The egg mass is typically arranged in a loosely arranged cluster.

The brown stink bug ranges from Quebec and New Hampshire south to Florida and west to California and British Columbia (Froeschner 1988). It is composed of 2 subspecies—*E. servus euschistoides* (Vollenhoven) and *E. servus servus* (Say)—which intergrade at ≈ 40 degrees north latitude (McPherson 1982). *E. servus servus* is the subspecies of brown stink bug examined during this study. It is found throughout the Southeast and west to California (McPherson 1982). This is one of the most commonly collected stink bugs in soybean (McPherson et al. 1994, McPherson 1996) and cotton (Roach 1988).

Euschistus tristigmus (Say), the dusky stink bug (Fig. 5a–b). Length, 0.98–1.14 mm; diameter, 0.86–1.02 mm. Form subelliptical. Operculum weakly convex and circular. Chorion spinose, with sculpturing in a weakly defined triangular pattern. Micropylar pro-

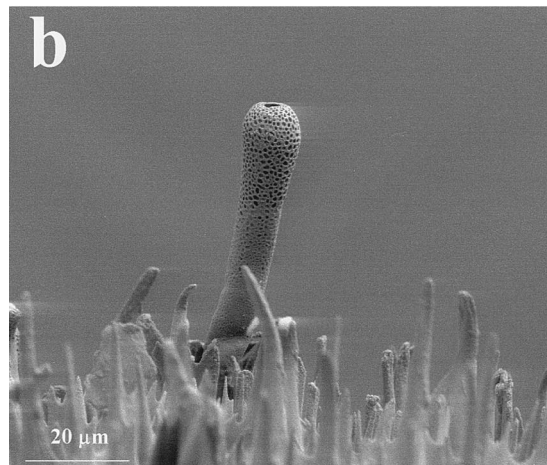
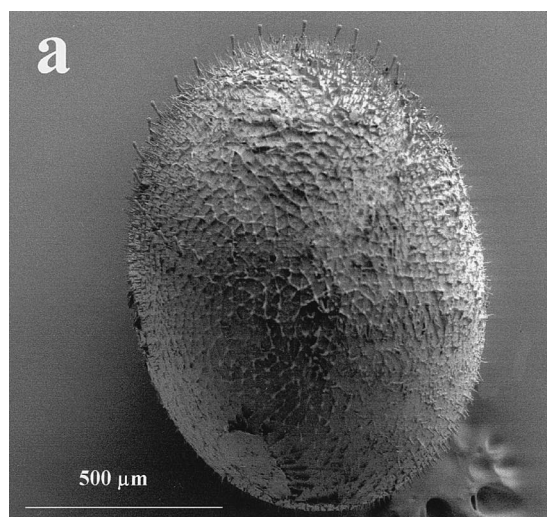


Fig. 4. *E. servus* (Say). (a) Lateral view of chorion. (b) Micropylar process.

cesses 28–39, weakly clavate. Surface of micropyle porous. Micropylar aperture located at apex of micropyle. Average micropylar length, 0.05 mm (Table 1). Color white or cream.

The egg mass of this species has been reported to have a maximum of 28 eggs per cluster (Woodside 1946), which was the maximum size observed during this study. The eggs were laid in loosely arranged, irregular clusters.

The dusky stink bug ranges from Quebec and Maine south to Florida and west to Washington (McPherson 1982, Froeschner 1988). Similarly to *E. servus*, *E. tristigmus* is composed of both a northern and a southern subspecies, which intergrade at ≈ 41 degrees north latitude (McPherson 1982). *E. tristigmus tristigmus* (Say) is the subspecies examined during this study. It ranges throughout the southeastern United States, reaching as far north as central Illinois. This stink bug has been collected in low numbers in soybeans (McPherson et al. 1993) and cotton (Barbour et al. 1988) in the Southeast.

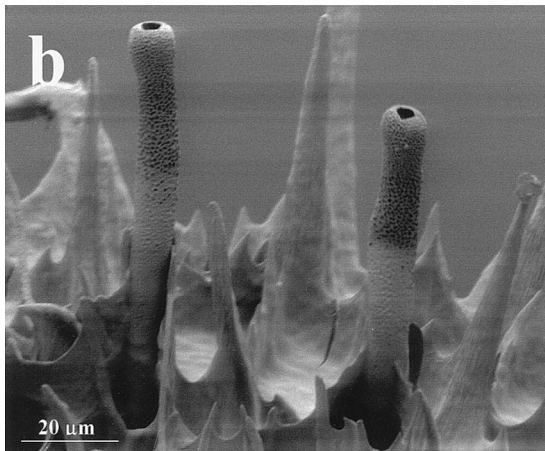
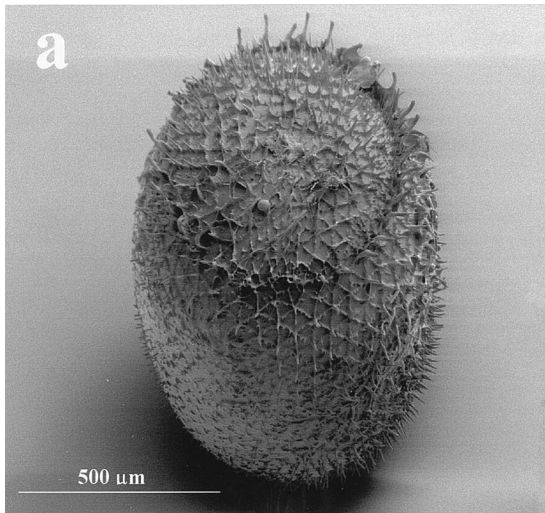


Fig. 5. *E. tristigmus* (Say). (a) Lateral view of chorion. (b) Micropylar processes.

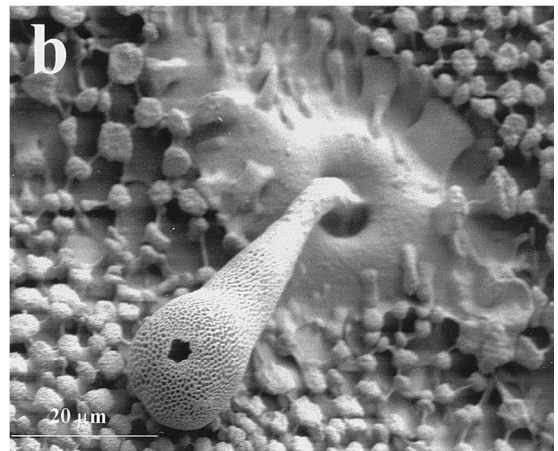
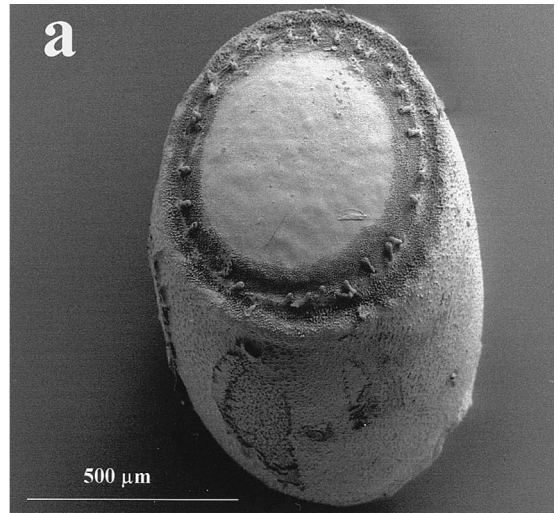


Fig. 6. *N. viridula* (L.). (a) Dorsolateral view of chorion. (b) Micropylar process.

Nezara viridula (L.), the southern green stink bug (Fig. 6a and 6b). Length, 1.02–1.26 mm; diameter, 0.73–0.84 mm. Form cylindrical. Operculum flat and circular. Chorion nearly smooth. Chorionic pattern, if present, obscure. Micropylar processes enclosed within a slightly depressed ring, surrounded by a thickened, dark band. Processes 28–40, strongly clavate. Surface of micropyle porous. Micropylar aperture located dorsally near apex of micropyle. Average micropylar length, 0.04 mm (Table 1). Color cream to yellowish.

The egg mass size of this species contained as many as 151 eggs per cluster. The eggs are arranged in very tight rows whose numbers increase toward the middle of the cluster and proportionally decrease toward either end, often giving the egg mass a hexagonal appearance.

The southern green stink bug is a cosmopolitan species that is very common in the southern United States. It ranges from Virginia south to Florida and west to Oklahoma and Texas (Froeschner 1988). In Georgia, this stink bug typically is the most commonly

collected stink bug in both crops (McPherson et al. 1993, McPherson et al. 1994; C.S.B., unpublished data) and is second only to *A. hilare* in the Carolinas (Barbour et al. 1988, Roach 1988).

Oebalus pugnax (F.), the rice stink bug (Fig. 7a and 7b). Length, 0.78–0.84 mm; diameter, 0.59–0.67 mm. Form cylindrical. Operculum flat or nearly so and circular. Chorion nearly smooth. Chorionic pattern, if present, obscure. Micropylar processes 50–79, capitate, appearing somewhat mushroom-shaped (not visible in Fig. 7a). Surface of micropyle porous. Micropylar aperture located dorsally near apex of micropyle. Average micropylar length, 0.04 mm (Table 1). Color green to red at maturity. Egg masses of this species are distinct in their arrangement. They are laid in alternating positions in two rows (Ingram 1927, Douglas and Ingram 1942, Esselbaugh 1946, Odglen and Warren 1962). The reported maximum number of eggs per cluster ranges from 44 (Esselbaugh 1946, Odglen and Warren 1962) to 47 (Douglas and Ingram 1942). A maximum of 45 eggs per cluster was observed during this study.

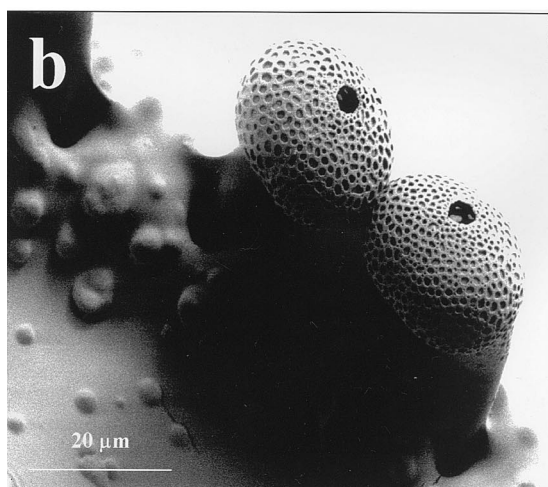
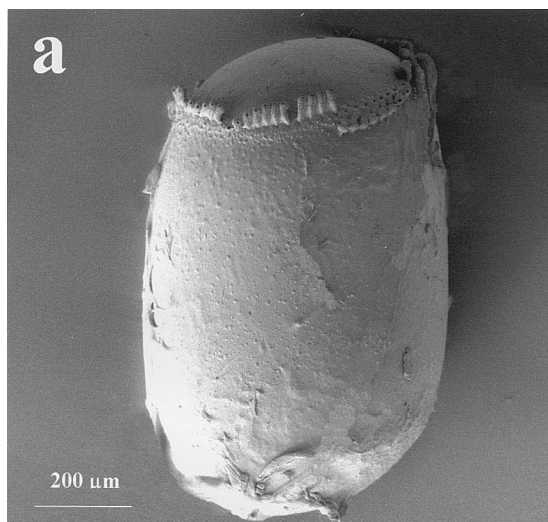


Fig. 7. *O. pugnax* (F.). (a) Lateral view of chorion. (b) Micropylar processes.

The rice stink bug ranges from Connecticut south to Florida and west to Arizona (Froeschner 1988). It is an occasional pest of soybean (McPherson et al. 1993) and cotton (C.S.B., unpublished data), but generally is associated with rice and other grasses (Panizzi 1997).

Piezodorus guildinii (Westwood) (Fig. 8a and 8b). Length, 0.88–1.08 mm; diameter, 0.58–0.80 mm. Form cylindrical. Operculum flat and elliptical. Chorion heavily spinose and irregularly reticulate, almost appearing woolly. Micropylar processes 31–44, somewhat fusiform. Surface of micropyle appearing smooth. Micropylar aperture located at apex of micropyle. Average micropylar length, 0.11 mm (Table 1). Color light to reddish brown with black spines, a light transverse stripe often visible medially.

As with *O. pugnax*, egg masses of *P. guildinii* were deposited in alternating positions in 2 rows. The maximum number of eggs per cluster was 28. The last egg always was deposited on its side with its distal end

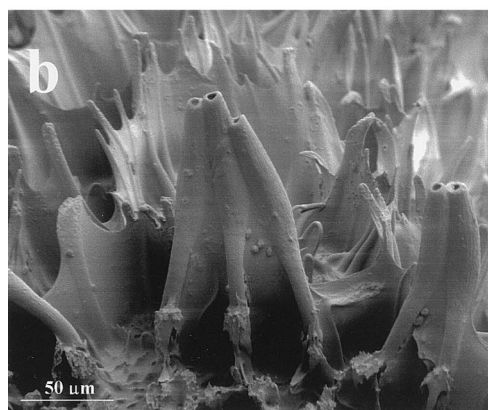
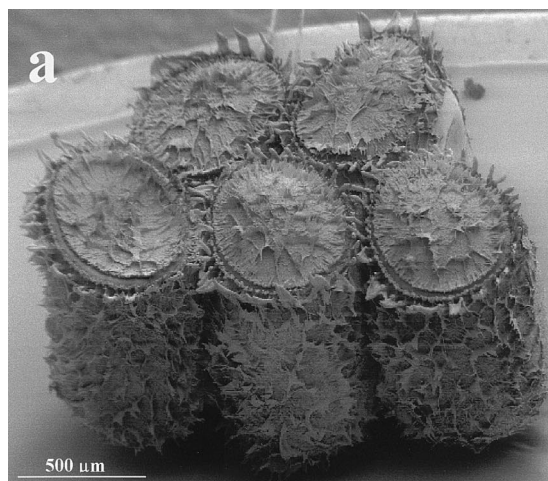


Fig. 8. *P. guildinii* (Westwood). (a) Lateral view of chorion. (b) Micropylar processes.

facing away from the cluster in all egg masses examined. The darker, heavily spined eggs of *P. guildinii* allows this species to be distinguished easily from the smooth eggs of *O. pugnax*, which is the only other stink bug in the 2 crops with eggs arranged in two rows.

Piezodorus guildinii is a South and Central American species that recently has spread into the United States (Panizzi and Slansky 1985). In America north of Mexico, it has been collected in Florida, Georgia, and New Mexico. This is an important pest of soybeans in South America (Panizzi and Slansky 1985) but generally is present in low numbers in the Southeast (McPherson et al. 1993). It also has been reported as an occasional pest of cotton (Panizzi 1997).

Thyanta custator accerra McAtee, the redshouldered stink bug (Fig. 9a–9b). Length, 0.88–1.04 mm; diameter, 0.76–0.88 mm. Form subcylindrical. Operculum convex and circular, a dark ring within it in mature specimens. Chorion salebrose (rough), surface less coarse medially. Micropylar processes 18–25, clavate and slender. Surface of micropyle porous. Micropylar aperture located at apex of micropyle. Average micropylar length, 0.03 mm (Table 1). Color gray, with 1 or 2 darker transverse bands near proximal and

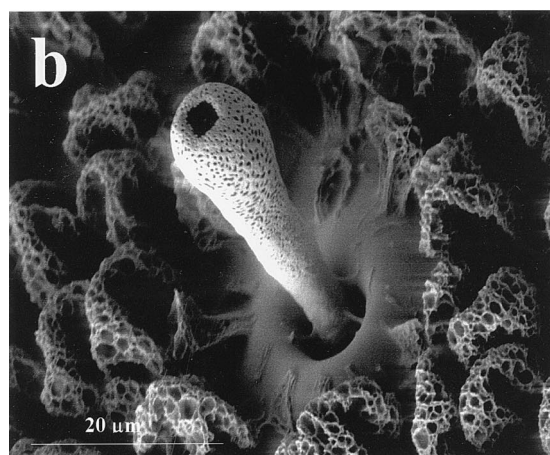
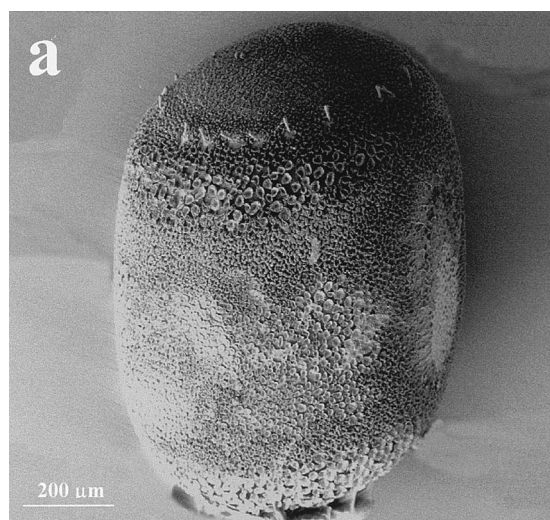


Fig. 9. *T. accerra* McAtee. (a) Lateral view of chorion. (b) Micropylar process.

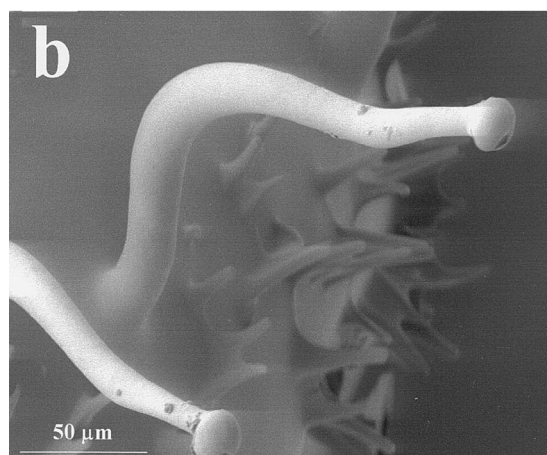
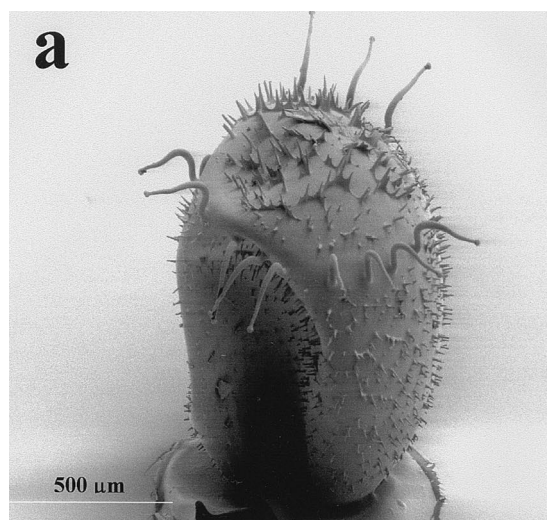


Fig. 10. *P. maculiventris* (Say). (a) Lateral view of chorion. (b) Micropylar processes.

distal portions of egg. Egg masses have been reported to contain a maximum of 72 eggs per cluster (Esselbaugh 1946). A maximum of 37 eggs was observed per cluster during this study. However, few egg masses ($n = 5$) were counted for this species. The eggs were loosely arranged in a somewhat irregular pattern in each observed egg mass.

The redshouldered stink bug ranges from Quebec and New York south to Florida and west to Montana and Utah (Froeschner 1988). It usually is present in low numbers in soybeans and cotton (Barbour et al. 1988; McPherson et al. 1993; C.S.B., unpublished data).

Podisus maculiventris (Say), the spined soldier bug (Fig. 10a and 10b). Length, 0.88–1.08 mm; diameter, 0.78–1.00 mm. Form subglobose to oval. Operculum convex and circular. Chorion spinose, surface with irregular reticulations. Long spines densely clustered on operculum. Spines covering the remainder of the chorion shorter and loosely arranged. Micropylar processes 12–19, sinuate and capitate. Surface of micropyle appearing smooth. Micropylar aperture located

ventrally near apex of micropyle. Average micropylar length, 0.29 mm (Table 1). Color pale yellow to metallic blue.

The egg mass of this species has been reported to contain a maximum of 27 (Olsen 1910) to 57 (Esselbaugh 1946). The largest egg mass observed during this study contained 35 eggs. The eggs are loosely arranged within the cluster. The long micropylar processes and low total number of processes, as well as the metallic coloration of the egg, make this egg easily discernible from all other species included in this study.

The spined soldier bug ranges from Quebec and Massachusetts south to Florida and west to California and British Columbia (Froeschner 1988). It is an important predator in many agricultural systems throughout much of its range and commonly is found in both soybean (McPherson et al. 1993) and cotton (C.S.B., unpublished data).

Overall Comparisons. When the relative sizes of the eggs of the 10 species were compared, they were

found to be significantly different (length: $P \leq 0.0001$, diameter: $P \leq 0.0001$) (Table 1). Eggs of *A. hilare* were the largest (length and diameter), and those of *T. c. accerra* were the smallest. There also were significant differences in the micropylar lengths of the various species ($P \leq 0.0001$). *P. maculiventris* had much longer micropylar processes than any other species, followed by *P. guildinii*. *T. c. accerra* had the shortest micropylar processes. Typically, there were distinct gaps in the average number of micropylar processes among species (Table 1). *P. maculiventris* had the fewest (16), followed by *T. c. accerra* (22). There was an overlap in number of processes among *P. guildinii* and the *Euschistus* species. *O. pugnax* had the greatest number of micropylar processes with an average of 67 per egg.

The species examined also may be broadly separated based upon the morphology of the chorion. A spinose chorion is characteristic of *P. guildinii*, *P. maculiventris*, and the *Euschistus* species. The chorion is coarsely reticulate for *A. hilare* and rough for *T. c. accerra*. Finally, the chorions of *O. pugnax* and *N. viridula* appear relatively smooth.

Discussion

Descriptions, as well as the distributions, of the eggs of the stink bugs that may be encountered in soybeans or cotton in the Southeast are given. The eggs of most of these species are differentiated easily from one another by simple morphological differences. However, the *Euschistus* species are difficult to distinguish from one another, and it may be necessary to use egg measurements to make a determination. *E. servus* is by far the most commonly collected species within this genus on soybeans and cotton in the southeastern United States and readily reproduces on these crops. Therefore, *Euschistus* sp. eggs collected from either crop in this region most likely will be *E. servus*. However, the other 3 species may occasionally form moderately sized populations as well. Eggs of *E. quadulator* are the smallest of the 4 species examined and may be separated readily from the other 3 using egg length and diameter. Additionally, the micropylar processes are longer in this species than in the other 3. There is some overlap in the egg measurements of *E. obscurus*, *E. servus*, and *E. tristigmus*, and it may be impossible to make a species-level determination among these 3 species using only the morphology of the egg.

Using eggs to aid in determining which species are reproducing in the field can have important implications for decisions concerning pest control. Eggs also allow a relatively simple means of determining whether or not predatory pentatomids are present in the system. The morphology and coloration of *P. maculiventris* allow it to be distinguished easily from phytophagous species. Of course there are limitations to using this stage alone in making determinations about which stink bugs are present. The egg masses are glued to the host plant and, typically, are not removed when using a sweep net or shake cloth. Also, the masses often are deposited on the undersides of leaves and may be overlooked when scouting. However,

when used in combination with traditional sampling techniques, random sampling for pentatomid eggs could increase the accuracy of monitoring stink bug abundance.

Key to the Genera of the Common Pentatomids Associated with Cotton or Soybeans

1. Chorion spinose (Figs. 2–5, 8, 10) 2
Chorion smooth, granulate, or reticulate (Figs. 1 and 6, 7, 10) 4
2. Micropylar processes 19 or fewer; processes sinuate and $> \frac{1}{4}$ length of egg; color metallic blue at maturity (Fig. 10) *Podisus*
Micropylar processes 26 or more; processes not sinuate and $< \frac{1}{4}$ egg length; color variable, never metallic blue 3
3. Micropylar processes somewhat fusiform (Fig. 8b), 31–44 in number; operculum flat; color reddish-brown (Fig. 8a) *Piezodorus*
Micropylar processes weakly clavate (e.g., Figs. 2–5), 26–39 in number; operculum somewhat convex, color white or cream *Euschistus*
4. Micropylar processes 47 or more 5
Micropylar processes 40 or fewer 6
5. Chorion coarsely reticulate (Fig. 1); micropylar processes 47–64 in number; color lemon yellow or pea green *Acrosternum*
Chorion apparently smooth (minute granules visible at high magnification) (Fig. 7); micropylar processes 50–79 in number; color green or red *Oebalus*
6. Chorion rough (Fig. 9); micropylar processes 18–25 in number; operculum somewhat convex; color gray with dark transverse bands *Thyanta*
Chorion smooth (Fig. 6); micropylar processes 28–40 in number; operculum flat; color cream to reddish orange *Nezara*

Acknowledgments

We express appreciation to John Shields (University of Georgia Electron Microscopy Laboratory) for his instructions on the use of the scanning electron microscope. We also thank Joe McHugh, John Ruberson, Gary Herzog, and Craig Bednarz (University of Georgia) for their critical reviews of this work, and the Georgia Agricultural Experiment Stations for partial funding.

References Cited

- Barbour, K. S., J. R. Bradley, Jr., and J. S. Bachelor. 1988. Phytophagous stink bugs in North Carolina cotton: an evaluation of damage potential, pp. 280–282. In *Proceedings Beltwide Cotton Conferences*. National Cotton Council of America, Memphis, TN.
- Bundy, C. S., R. M. McPherson, and G. A. Herzog. 1998. Stink bugs in a cotton/soybean ecosystem: impact on quality and yield, pp. 1172–1174. In *Proceedings Beltwide Cotton Conferences*. National Cotton Council of America, Memphis, TN.

- Coppel, H. C., and P. A. Jones. 1962. Bionomics of *Podisus* spp. associated with the introduced pine sawfly, *Diprion similis* (Hartig), in Wisconsin. Wisc. Acad. Sci. Arts Lett. 51: 31–56.
- Daugherty, D. M., M. H. Neustadt, C. W. Gehrke, L. E. Cavanah, L. F. Williams, and D. E. Green. 1964. An evaluation of damage to soybeans by brown and green stink bugs. J. Econ. Entomol. 57: 719–722.
- Deitz, L. L., J. W. Van Duyn, J. R. Bradley, Jr., R. L. Rabb, W. M. Brooks, and R. E. Stinner. 1976. A guide to the identification and biology of soybean arthropods in North Carolina. N.C. Agric. Exp. Stn. Bull. 238.
- Douce, G. K., and R. M. McPherson. 1991. Summary of losses from insect damage and costs of control in Georgia, 1989. Ga. Agric. Exp. Stn. Spec. Publ. 70.
- Douglas, W. A., and J. W. Ingram. 1942. Rice-field insects. U.S. Dep. Agric. Circ. 632.
- Esselbaugh, C. O. 1946. A study of the eggs of the pentatomidae (Hemiptera). Ann. Entomol. Soc. Am. 39: 667–691.
- Froeschner, R. C. 1988. Family Pentatomidae, pp. 544–597. In T. J. Henry and R. C. Froeschner [eds.], Catalog of the Heteroptera or true bugs of Canada and the continental United States. Brill, New York.
- Heidemann, O. 1911. Some remarks on the eggs of North American species of Hemiptera-Heteroptera. Proc. Entomol. Soc. Wash. 13: 128–140.
- Ingram, J. W. 1927. Insects injurious to the rice crop. U.S. Dep. Agric. Farm Bull. 1543.
- Marston, N. L., G. T. Schmidt, K. D. Biever, and W. A. Dickerson. 1978. Reaction of five species of soybean caterpillars to attack by the predator, *Podisus maculiventris*. Environ. Entomol. 7: 53–56.
- McPherson, J. E. 1982. The Pentatomioidea (Hemiptera) of northeastern North America with emphasis of the fauna of Illinois. Southern Illinois University Press, Carbondale and Edwardsville, IL.
- McPherson, R. M. 1996. Relationship between soybean maturity group and the phenology and abundance of stink bugs (Heteroptera: Pentatomidae): impact on yield and quality. J. Entomol. Sci. 31: 199–208.
- McPherson, R. M., G. K. Douce, and R. D. Hudson. 1993. Annual variation in stink bug (Heteroptera: Pentatomidae) seasonal abundance and species composition in Georgia soybean and its impact on yield and quality. J. Entomol. Sci. 28: 61–72.
- McPherson, R. M., J. W. Todd, and K. V. Yeargan. 1994. Stink bugs, pp. 87–90. In L. G. Higley and D. J. Boethel [eds.], Handbook of soybean insect pests. Entomological Society of America, Lanham, MD.
- McPherson, R. M., D. J. Boethel, J. E. Funderburk, and A. T. Wier. 1995. The effect of alternative southern green stink bug (Heteroptera: Pentatomidae) insecticide controls on soybean pest management, quality and yield. J. Entomol. Sci. 30: 216–236.
- Odglen, G. E., and L. O. Warren. 1962. The rice stink bug, *Oebalus pugnax* (F.) in Arkansas. Ark. Agric. Exp. Stn. Rep. Ser. 107.
- Olsen, C. E. 1910. Notes on breeding Hemiptera. J. N.Y. Entomol. Soc. 18: 39–42.
- Panizzi, A. R. 1997. Wild hosts of pentatomids: ecological significance and role in their pest status on crops. Annu. Rev. Entomol. 42: 99–122.
- Panizzi, A. R., and F. Slansky, Jr. 1985. Revision of phytophagous pentatomids (Hemiptera: Pentatomidae) associated with soybean in the Americas. Fla. Entomol. 68: 184–214.
- Riley, D. G., G. K. Douce, and R. M. McPherson [eds.]. 1997. Summary of losses from insect damage and costs of control in Georgia, 1996. Ga. Agric. Exp. Stn. Spec. Publ. 91.
- Roach, S. H. 1988. Stink bugs in cotton and estimation of damage caused by their feeding on fruiting structures, pp. 292–294. In Proceedings Beltwide Cotton Conferences. National Cotton Council of America, Memphis, TN.
- Rolston, L. H. 1974. Revision of the genus *Euschistus* in Middle America (Hemiptera: Pentatomidae; Pentatomini). Entomol. Am. 48: 1–103.
- SAS Institute. 1989. SAS user's guide: statistics. SAS Institute, Cary, NC.
- Sorenson, C. J., and E. W. Anthon. 1936. Preliminary studies of *Acrosternum hilaris* (Say) in Utah orchards. Utah Acad. Sci. 8: 229–232.
- Southwood, T. R. E. 1956. The structure of the eggs of the terrestrial Heteroptera and its relationship to the classification of the group. Trans. R. Entomol. Soc. Lond. 108: 163–221.
- Underhill, G. W. 1934. The green stinkbug. Va. Agric. Exp. Stn. Bull. 294.
- Wene, G. P., and L. W. Sheets. 1964. Notes on and control of stink bugs affecting cotton in Arizona. J. Econ. Entomol. 57: 60–62.
- Whitcomb, W. H., and K. Bell. 1964. Predaceous insects, spiders, and mites of Arkansas cotton fields. Bull. Ark. Exp. Stn. 690.
- Whitmarsh, R. D. 1917. The green soldier bug. Ohio Agric. Exp. Stn. Bull. 310: 519–552.
- Wiedenmann, R. N., J. C. Legaspi, and R. J. O'Neil. 1996. Impact of prey density and facultative plant feeding on the life history of the predator *Podisus maculiventris* (Heteroptera: Pentatomidae), pp. 94–118. In O. Alomar and R. N. Wiedenmann [eds.], Zoophytophagous Heteroptera: implications for life history and integrated pest management. Thomas Say Publications in Entomology, Entomological Society of America, Lanham MD.
- Woodside, A. M. 1946. Life history studies of *Euschistus servus* and *E. tristigmus*. J. Econ. Entomol. 39: 161–163.

Received for publication 9 August 1999; accepted 4 November 1999.